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Westinghouse Electric Corporation  
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**WANL-PR (DDD)-004**  
**Sept 1, To Nov 30, 1968**  
**Quarterly Progress Report Phase II**  
**CASCADED THERMOELECTRIC**  
**TEST GENERATOR**

CONTRACT 052106

NAS 7-100

**Westinghouse Astronuclear Laboratory**



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**TEST GENERATOR**

**JPL CONTRACT 952196**

## TECHNICAL CONTENT STATEMENT

This report contains information prepared by the Westinghouse Astronuclear Laboratory under J. P. L. subcontract. Content of this report is not necessarily endorsed by the Jet Propulsion Laboratory, California Institute of Technology, or the National Aeronautics and Space Administration.

INFORMATION CATEGORY	
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## TABLE OF CONTENTS

<u>Section</u>		<u>Page</u>
	ABSTRACT	V
1.0	INTRODUCTION	1-1
	Progress Summary	1-1
2.0	TECHNICAL DISCUSSION	2-1
	Design Status	2-1
	Tantalum Electrical Heater	2-1
	Multi-Foil Insulation	2-2
	SiGe Module	2-2
	Heat Pipe	2-2
	PbTe Tubular Module	2-2
	Heat Sink	2-2
	Structural Support System	2-3
	Thermal Insulation	2-3
	Instrumentation	2-3
	Vacuum Chamber	2-4



## ABSTRACT

This report covers the work performed under JPL contract 952196 for the "Design and Fabrication of a Cascaded SiGe/PbTe Thermoelectric Generator" for the period September 1 to November 30, 1968. This effort is being performed in two phases: Phase I consisted of a detailed design and analysis of the cascaded generator, and Phase II consists of the fabrication and check-out testing of the system. The work reported herein covers the status of the test generator fabrication under the Phase II portion of the contract. Also included is a brief discussion of minor design modifications that have been incorporated since the completion of Phase I.

## 1.0 INTRODUCTION

A cascaded SiGe/tubular PbTe thermoelectric test generator is being designed and fabricated under contract to the Jet Propulsion Laboratory (JPL), Pasadena, California. This effort is being performed in two phases: Phase I included the detailed design and analysis of the cascaded test generator and Phase II includes the fabrication and initial check-out testing of the system. This report covers the work performed during the third quarter of the contract effort (September 1 to November 30, 1968). Primary emphasis during this period has been on the completion of detailed manufacturing drawings, on the initiation and partial completion of component fabrication, on the design and procurement of a Multi-Foil insulation package and on thermal cycling tests of tantalum specimens coated with zirconia and alumina. This report includes a brief status summary of the major system components along with the modifications that have resulted from the detailed design study. No conclusions or recommendations are included in this report.

### Progress Summary

During the period covered by the third quarter of this contract, the following was accomplished:

- (1) Assembly and detail manufacturing drawings for the cascaded system have been completed.
- (2) Materials for fabricating the cascaded system components have been procured.
- (3) Fabrication of all system components other than the tantalum heater, and the PbTe tubular module has been initiated and fabrication of some components has been completed.
- (4) Purchase Order 59-XE-99888 for the procurement of a Multi-foil Insulation System from Thermo Electric Corporation was submitted to JPL for approval and subsequent approval obtained. Fabrication of this component has been initiated.
- (5) Purchase Order 59-WG-91424 for the procurement of tantalum components for the electrical heater from Customs Systems Engineering has been submitted to JPL for placement approval.
- (6) Check-out tests of a vacuum system provided to WANL by JPL have been completed.
- (7) Thermal cycling tests of tantalum specimens coated with alumina and zirconia have been completed. Emissivity tests of these specimens have been initiated.

## 2.0 TECHNICAL DISCUSSION

The status of the primary cascaded systems components are discussed below. Minor modifications to some of the components have resulted from the detailed design effort and are discussed where applicable.

### Design Status

Detail manufacturing drawings for the cascaded system components have been completed. An assembly drawing indicating placement of the cascaded thermoelectric test generator in the vacuum chamber, all instrumentation, and the routing of all instrumentation has been completed. A draft of an assembly procedure for the cascaded system has been completed and is being reviewed.

### Tantalum Electrical Heater

Purchase Order 59-WG-91424 for the procurement of tantalum heater components from Customs Systems Engineering has been submitted to JPL for approval. Customs Systems will provide the heater components; welding of the components including the application of an emissivity coating and assembly of the heater will be performed by WANL.

Thermal cycling tests of tantalum specimens coated with zirconia and alumina have been completed. These tests are being performed to enable selection of a coating for the tantalum heater to improve the heat transfer capability. Twenty-five thermal cycles from room temperature to 2200°F in a vacuum of  $5 \times 10^{-8}$  torr were performed. A total of 532 hours of specimen operation at a temperature of 2200°F was accumulated. Visual inspection of the specimens indicated no deleterious effects due to cycling, although a slight discoloration of the tantalum/zirconia specimen was observed. Emissivity tests will be performed on the specimens and the results compared to tests performed prior to cycling. The coating for the tantalum heater will be selected after test results have been analyzed.

The inner diameter of the tantalum heater was increased from 4.0 inches to 4.18 inches to provide 0.25 inch clearance between the heater and the "across corners" diameter of the SiGe hot shoes. This clearance is sufficient to prevent contact between the SiGe hot shoes and the heater at operating temperature. The increased diameter will require a 5 percent increase in total power input to the tantalum heater.



### Multi-Foil Insulation Package

Purchase Order 59-XE-99888 for procurement of a Multi-Foil insulation system from Thermo Electron Corporation was submitted to JPL for placement approval and subsequent approval obtained. Fabrication of this component has been initiated.

### SiGe Module

SiGe couples have been fabricated. Fabrication of the copper wedges and Inconel 718 material rings is nearing completion. Delivery of Inconel 718 material for fabricating the "hold down" bars has been delayed but will not affect the unit delivery date.

To insure the capability of disassembling the SiGe hot stage, all mating surfaces will be coated with boron nitride powder.

### Heat Pipe

Fabrication of the sodium heat pipe is nearing completion. Prior to assembly in the cascaded generator system, the heat pipe will be qualification tested under start-up and operating loads anticipated in the system check-out tests.

### PbTe Tubular Module

Fabrication of the PbTe tubular module has been temporarily stopped while the performance and destructive examination of modules being tested under other programs are reviewed. On the basis of results obtained to date, it appears that some modifications will be made to improve the tubular module performance. These modifications, if required, are not expected to affect the delivery date.

### Heat Sink

Fabrication of the water calorimeter is nearing completion. The calorimeter is fabricated in two halves, and will be clamped along with Grade A aluminum silicate inserts around the outer clad of the PbTe tubular module. The two halves of the calorimeter will be joined with stainless steel tubing so that only one water inlet and one water outlet is required. Thermocouples inside the vacuum chamber will monitor the inlet and outlet water temperature.

### Structural Support System

Fabrication of the structural support components has been initiated. The length and diameter of these components were modified to accommodate the JPL vacuum chamber.

### Thermal Insulation

MinK 2020 (Johns-Manville) insulation has been substituted for MinK 2002 indicated in the Phase I design. This substitution was made because of material availability and will not affect system performance since both insulations have comparable properties. Recently completed tests of MinK 2020 insulation on RCA in-house projects, at approximately 1850°F, indicated satisfactory performance of the material for the 3000 hours of test operation. A layer of 3/16 inch microquartz insulation has been added to each end of the SiGe stage to eliminate any tolerance problems that could exist between the SiGe stage and the Multi-Foil insulation package.

### Instrumentation

Several additional thermocouples have been added to the cascaded system over those indicated in Phase I. Three thermocouples have been added to the cold side of the SiGe module and five thermocouples are located to monitor the outer surface temperature of the Multi-Foil insulation package. Two types of thermocouples will be used to record temperatures in the SiGe stage; 12 tungsten/rhenium thermocouples will be cemented in the p-type hot shoes and a chromel/alumel thermocouples will be welded to the electrical connectors in the cold stack. The tungsten/rhenium thermocouples will be fabricated from .005 inch diameter wire consisting of 75 percent W/25 percent Re and 97 percent W/3 percent Re. The thermocouples will be encased in alumina tubing within the SiGe stage and from the stage entrance to the vacuum chamber instrumentation ports high temperature silicon fibers sleeving will be used. The remaining 26 system thermocouples will be chromel/alumel; 8 of these couples will be sheathed to monitor the heat pipe and PbTe tubular module inner clad temperatures. Two tungsten/rhenium and two chromel/alumel thermocouples will be calibrated in addition to the vendor certification.

### Vacuum Chamber

Check-out tests of the vacuum chamber provided to WANL by JPL have been completed. These tests indicated satisfactory operation. A vacuum of  $2 \times 10^{-8}$  torr was achieved using only the sorption pumps for the initial startup of the ion system.